Thermodynamic and Numerical Properties of a Gyrokinetic Plasma*

W. W. Lee
Princeton Plasma Physics Laboratory
Princeton, NJ 08543

The study of thermodynamic properties of a simulation plasmas has a long history, since they are intrinsically related to the numerical schemes used for the particle simulation. The effects on the simulation due to finite-size particle and the discovery of convective cells in magnetized plasmas are a few of the examples in the past. In this paper, we will describe the thermodynamic properties of a gyrokinetic plasma in terms of fluctuation-dissipation theorem, entropy production, and energy conservation. Some of these issues have also been addressed before. For example, the drastic noise reduction in an electrostatic gyrokinetic simulation plasmas has been explained by the change in the linear dielectric function.[1] The decade old puzzle concerning the electron response in a finite β gyrokinetic plasma[2] has recently been resolved,[3] which leads to the formulation of the perturbative split-weight simulation scheme.[3] In view of the recent work on the relationship of compressional and shear Alfvén waves between MHD and gyrokinetic descriptions,[4] we will review these properties and explore the possibility of simulating kinetic-MHD physics via particle codes. The recent concern about energy conservation in gyrokinetic particle codes and their use for transport time scale simulation associated with entropy production and magnetic equilibria will also be discussed.

* Work supported by US DoE.

[1] J. A. Krommes, W. W. Lee and C. Oberman, Phys. Fluids **29** 2421(1986).
[2] J. A. Krommes, Phys. Rev. Lett. **70**.3067 (1993); Phys. Fluids B **5**, 2405 (1993).
[3] W. W. Lee, J. L. V. Lewandowski, T. S. Hahm, and Z. Lin, Phys. Plasmas **8**, 4435 (2001).
[4] W. W. Lee and H. Qin, Phys. Plasmas (to appear).